Electronic Part Total Cost of Ownership

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Part Total Ownership Cost

Total Ownership Cost =

Purchase price

+ Part selection

+ Part approval and adoption costs (including supplier qual)

+ Part qualification (general and/or product specific)

+ Part- and product- specific NRE costs

+ Assembly, test and rework (manufacturing)

+ Cost of failure in the field

+ Obsolescence and other supply chain problem resolutions

The effective total cost of ownership of an electronic part to an organization is usually many

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History of this Model

- This model is the result of a CALCE Consortium project performed November 2006 – October 2007
- The project was driven by Ericsson (telecom)
- Several projects to extend this model have been proposed to start in November 2008

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Motivation for this Model

- Enabling the estimation of the total cost of ownership for specific parts would influence initial component selection and provide guidance on what actions taken at the component management level provide the maximum payback to an organization
- Provide a business case for retiring existing components from databases (in favor of newer components)
- Determine the impact of part-specific supply chain disruptions
- Determine the value of reusing components in multiple designs

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Viewpoint

- This model was developed from the part management organization perspective and is designed to enable fundamental part management decisions (as opposed to product management decisions)
- Why?
  - Because the supply chain constraints are part-specific, not product-specific
  - Product-specific part management decisions are enabled by other tools, e.g., MOCA

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Model Overview

The model is actually composed of three different models:

1) "Maintenance" Cost
   - Initial approval and adoption
   - Product-specific approval and adoption
   - Annual maintenance support
   - Annual product support
   - Procurement costs (contract negotiation, purchase order generation, etc.)
   - Other NRE costs (CAD symbols, etc.)
2) Manufacturing Cost
   - Procurement costs (part costs)
   - Assembly costs
   - Inspection/test costs
   - Diagnosis and rework costs
3) Field Use Cost
   - Cost of failure
   - Repairs and spares

Also includes:

- Cost of money
- Inflation/deflation
- Obsolescence resolution
- Lifetime buy costs
- Inventory costs

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Maintenance Cost

The maintenance model captures all non-recurring costs associated with selecting, qualifying and purchasing the part (these costs may recur annually, but do not recur for each part instance).

$$C_{maint_i} = \frac{\left(C_{ia_i} + C_{pa_i} + C_{as_i} + C_{ps_i} + C_{ap_i} + C_{or_i} + C_{nonPSL_i} + C_{design_i}\right)}{(1+d)^i}$$

From ABC model:

C_{ia_i} = initial part approval and adoption cost
C_{pa_i} = product-specific approval and adoption
C_{as_i} = annual cost of supporting the part within the organization
C_{ps_i} = all costs associated with production support and part maintenance activities that occur every year that the part is in a manufacturing
C_{ap_i} (assembly) process for one or more products
C_{or_i} = purchase order generation cost
C_{nonPSL_i} = obsolescence case resolution costs
C_{design_i} = setup and maintenance for all non-PSL (Preferred Supplier List) part suppliers
= non-recurring design-in costs associated with the part
d = discount rate on money
i = year (starting at year 0)

ABC = Activity Based Cost

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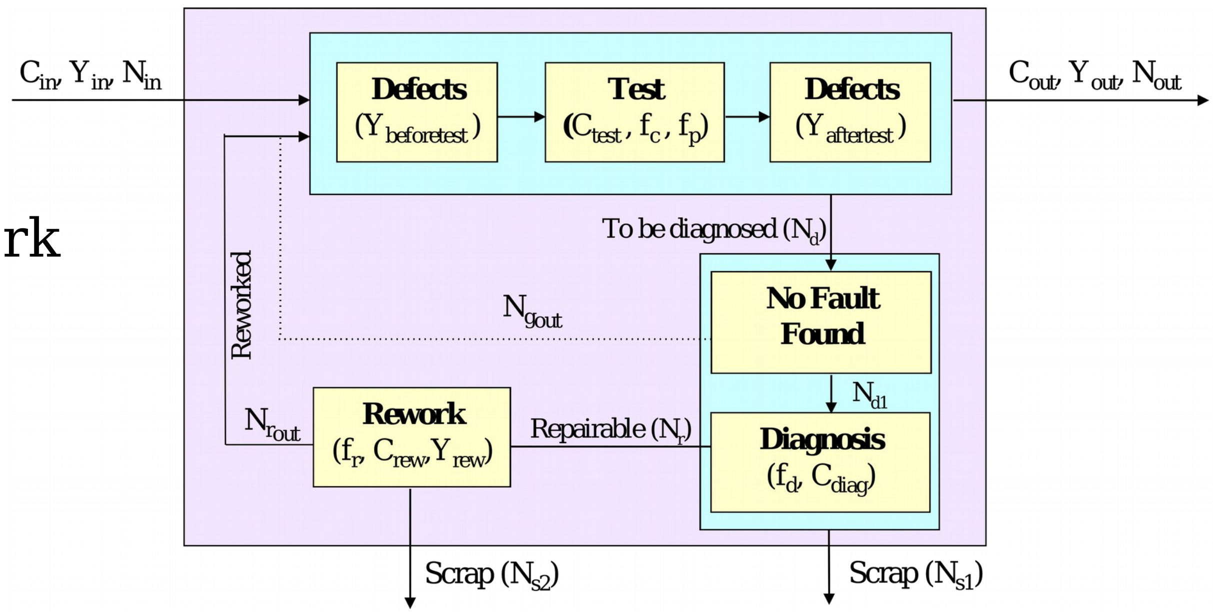
Manufacturing (Assembly) Cost

The manufacturing model captures all the recurring costs associated with the part: purchase price, assembly cost (assembly into the system), and recurring functional test/diagnosis/rework costs.

$$C_{manuf_i} = \frac{N_i C_{out_i}}{(1+d)^i}$$

- N_i = total number of products manufactured in year i
- C_{out_i} = output cost/part from the model shown below
- C_{in_i} = incoming cost/part $= P_i + C_{a_i}$
- P_i = purchase price of one instance of the part in year i
- C_{a_i} = assembly cost of one instance of the part in year i

Test/diagnosis/rework model used to calculate C_{out}



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Field Use Model

The field use model captures the costs of warranty repair and replacement due to product failures associated with the part.

$$C_{fielduse_i} = \frac{\left(N_{f_i}(1-f)C_{repair} + N_{f_i} f C_{replace} + N_{f_i} C_{proc_i}\right)}{(1+d)^i}$$

N_{f_i} = number of failures under warranty in year i

f = fraction of failures requiring replacement (as opposed to repair) of the product.

C_{repair} = cost of repair per product instance

$C_{replace}$ = cost of replacing the product per product instance

C_{proc_i} = cost of processing the warranty returns in year i

Annual Effective Cost Per Part Site

$$C_i = \frac{\left(C_{maint_i} + C_{manuf_i} + C_{fielduse_i}\right)}{\sum_{j=0}^{i} N_j}$$

N_j is the number of products manufactured in year j

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Part Cost of Ownership Model
(Inputs and Outputs)

Inputs:
- Data describing the part
- A part usage profile (how many products are using the part, how many are used, and when the parts are needed)
- Data that describes the selection, manufacturing and support environment for the part

Outputs:
- Effective part cost (cumulative and annual)
- Effective part cost contributions
- Effective part cost allocated to each product

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Part Cost of Ownership Model
(Part-Specific Inputs)

Parameter	**Value**
Part name	SMT Capacitor Test Case
Existing part or new part?	Existing
Part type	Type 1
Approval/Support Level	PPL
Maturity Level of Part (lifecode)	2
Number of suppliers of part	7
How many of the suppliers are not PSL but approved?	5
How many of the suppliers are not PSL AND not approved?	0
Part-specific NRE costs	0
Expected obsolescence resolution	LTB
Number of I/O	2
Procurement lifespan (years)	
Item part price (in base year money)	0.015
Are order handling, storage and incoming inspection included in the part price?	Yes
Handling, storage and incoming inspection (% of part price)	10.00%
Defect rate per part (pre electrical test)	5
Surface mounting details	Automatic
Odd shape?	No
Part FIT rate in months 0-6 (failures/billion hours)	0.05
Part FIT rate in months 7-18 (failures/billion hours)	0.04
Part FIT rate after month 18 (failures/billion hours)	0.03

Currency can be selected

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Part Cost of Ownership Model
(Part-Specific Inputs)

Check all that apply:

- [ ] Component identification (including parameter review)
- [ ] Design adoption needed
- [ ] Special reliability/qualification testing
- [x] New volume and/or pricing negotiations
- [x] New CAD footprint and symbol needed
- [ ] Part never becomes obsolete
- [x] New supplier
- [ ] Include finite resource effects

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Part Cost of Ownership Model

(Non-Part-Specific Inputs)

GENERAL NON-PART-SPECIFIC INPUTS:		
Units	**Parameter**	**Value**
	Part price change profile (change with time)	Monotonic
%/yr	Part price change per year	-2.00%
	Part price change inflection point (year)	5
%	Manuf. (assembly) cost change per year	-3.00%
%	Manuf. (test, diagnosis, rework) cost change per year	-3.00%
%	Admin. cost change per year	0.00%
%	Effective after-tax discount rate (%)	10.00%
	Base year for money	1
	Additional material burden (% of price)	0.00%
US Dollar	LTB storage/inventory cost (per part per year)	0.010
%	LTB overbuy size (buffer)	10%
Months	Warranty length	18
%	Fielded product retirement rate (%/year)	5.00%
hr	Operational hours per year	8760
%	% of supplier setup cost charged to non-PSL, approved suppli	0.00%
	Currency to present results in	US Dollar

- Inflation/deflation
- Cost of money
- Lifetime buy parameters
- Currency
- etc…

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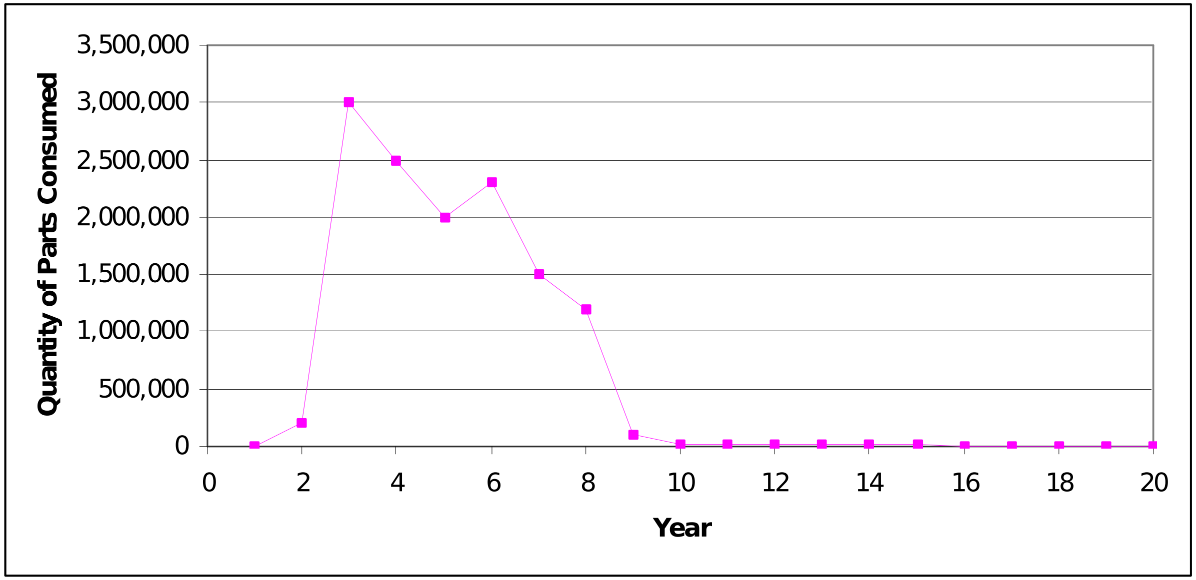
Part Cost of Ownership Model
(Part Usage Profile Inputs)

The user can enter the quantity of products using the part (and the quantities of parts required)



Year	Number of Products the Component is Designed Into or Produced Within	Total Number of Parts Consumed by Manufacturing
1	1	2000
2	2	200000
3	2	3000000
4	3	2500000
5	5	2000000
6	5	2300000
7	5	1500000
8	5	1200000
9	5	100000
10	5	25000
11	4	19000
12	3	17000
13	3	16000
14	2	10000
15	2	9500
16	1	6000
17	1	4000
18	1	2000
19	0	0
20	0	0

Total volume of parts = 12,910,500

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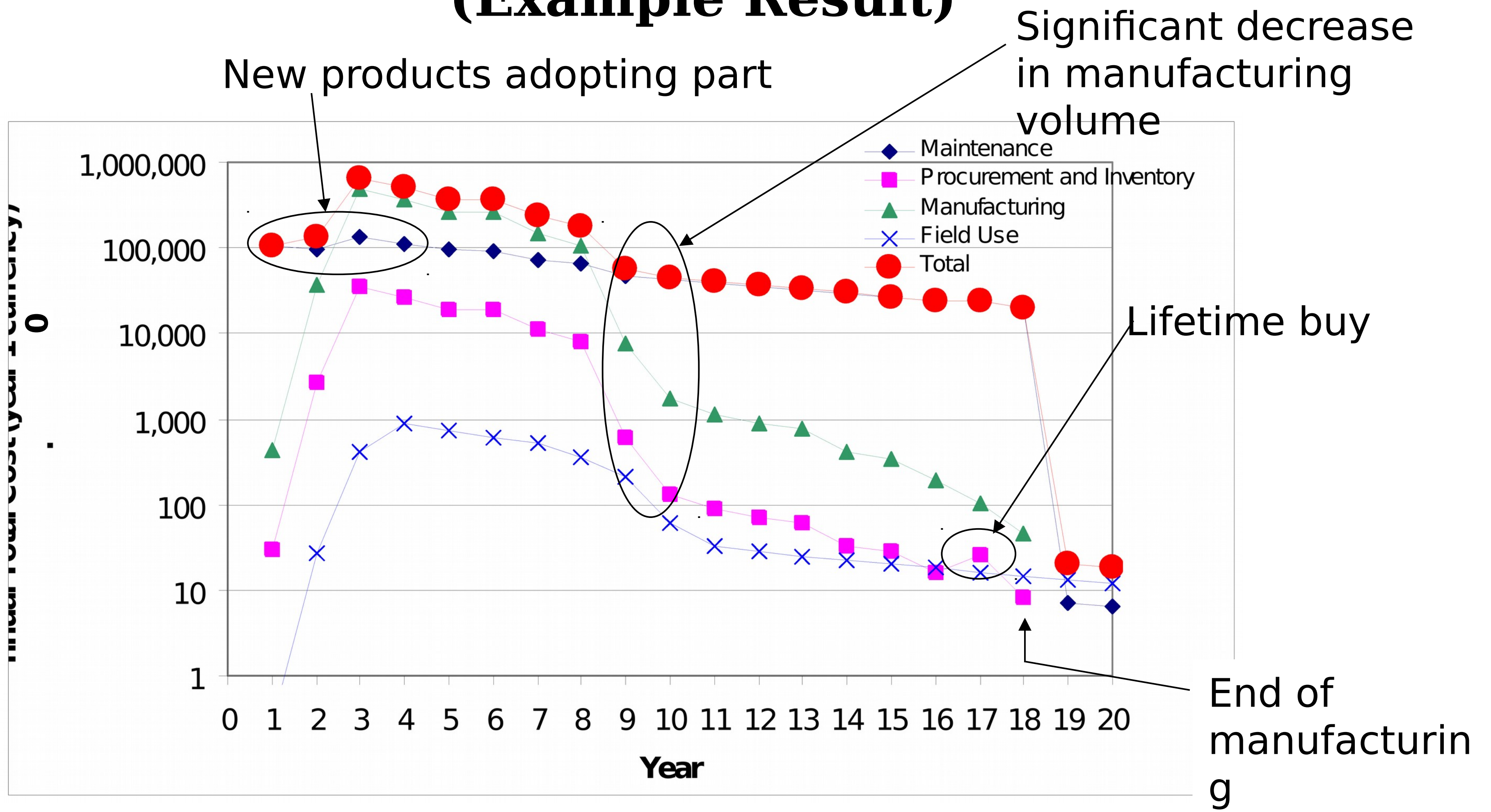
Part Cost of Ownership Model
(Example Result)



Total cost spent annually (all products using the part) on various aspects of the part's ownership

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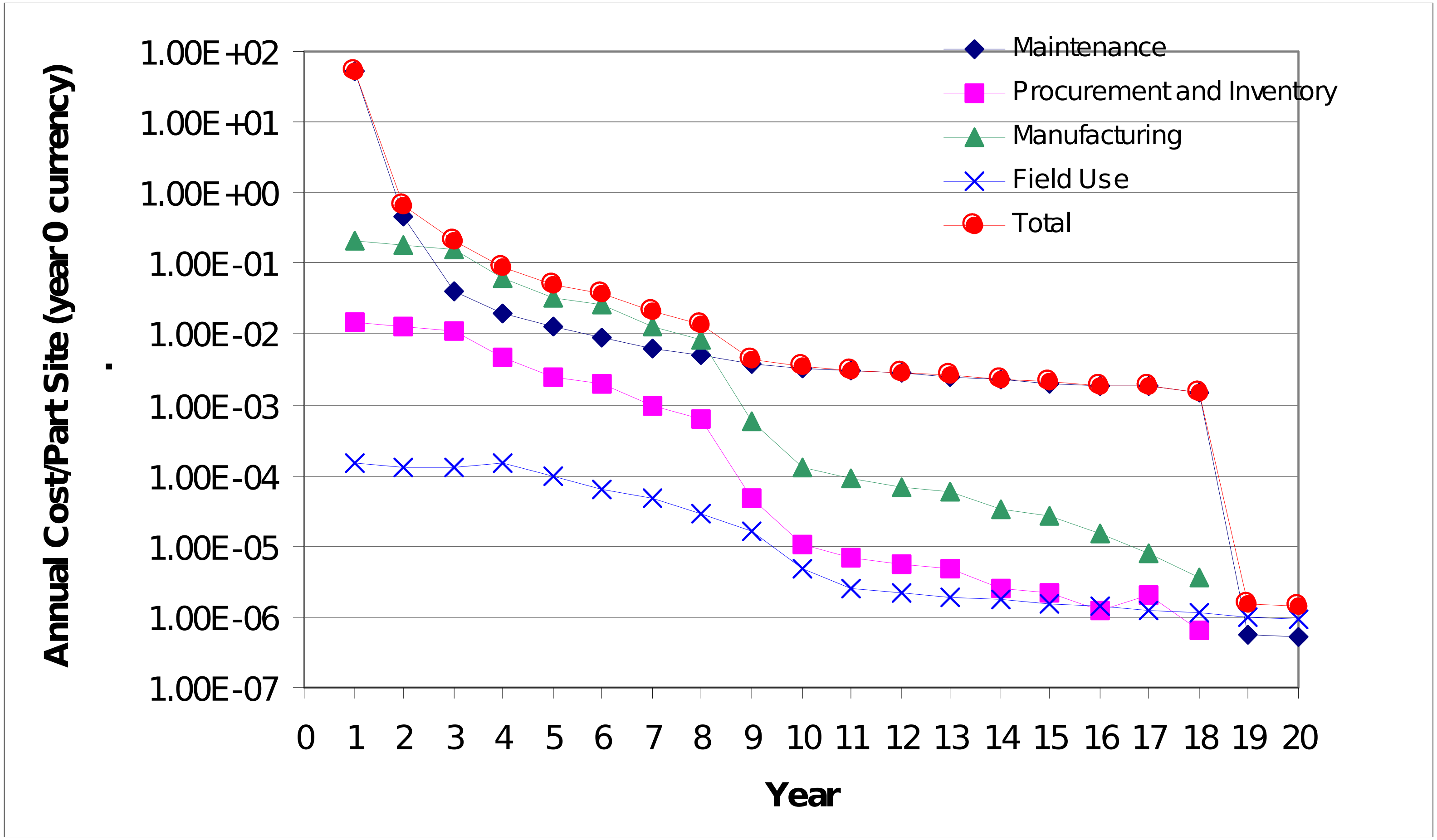
Part Cost of Ownership Model
(Example Result)



Part site = originally manufactured single part location

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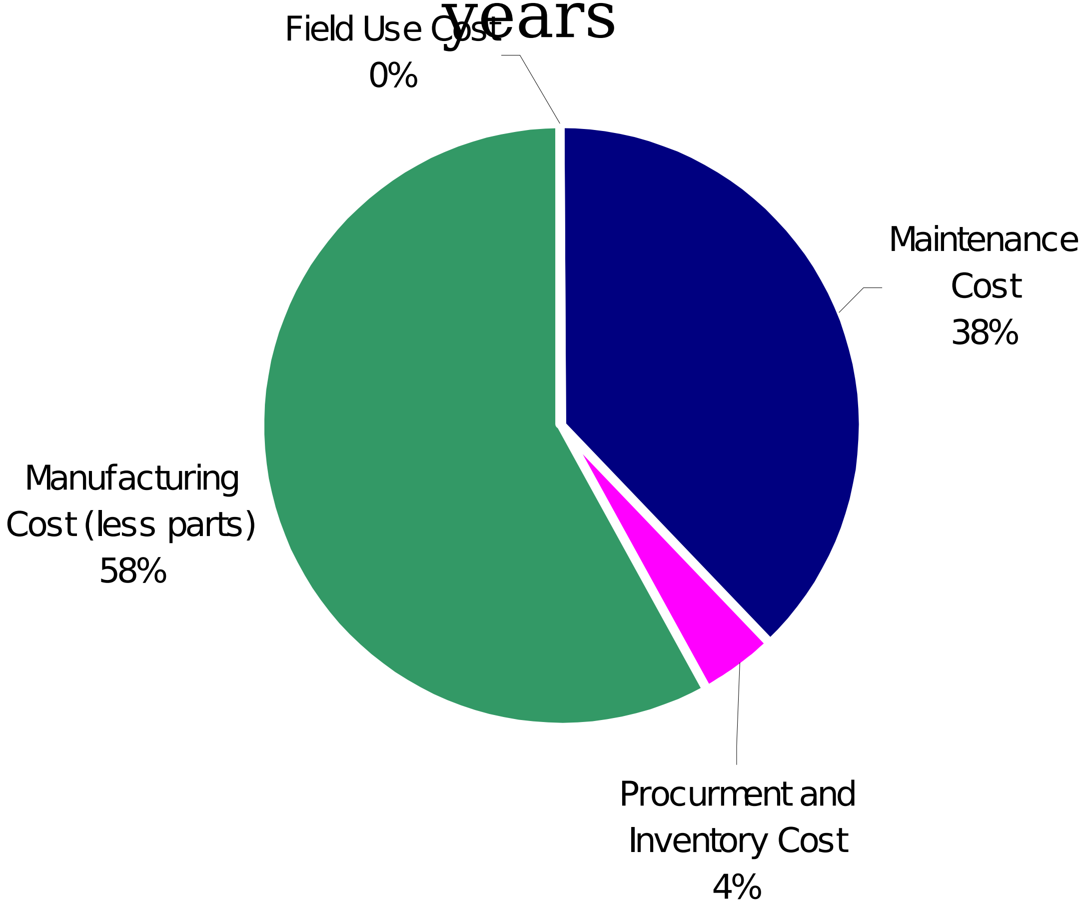
Part Cost of Ownership Model
(Example Result)

Effective cost per part purchased after 20 years



A $0.015 part has a total cost of ownership of $0.225/part

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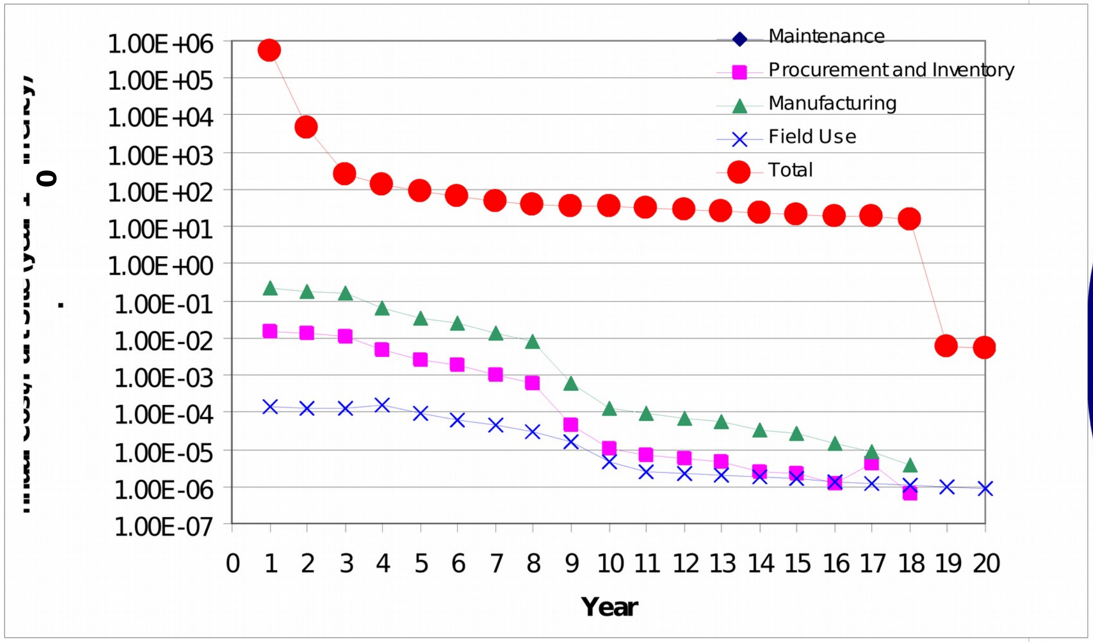
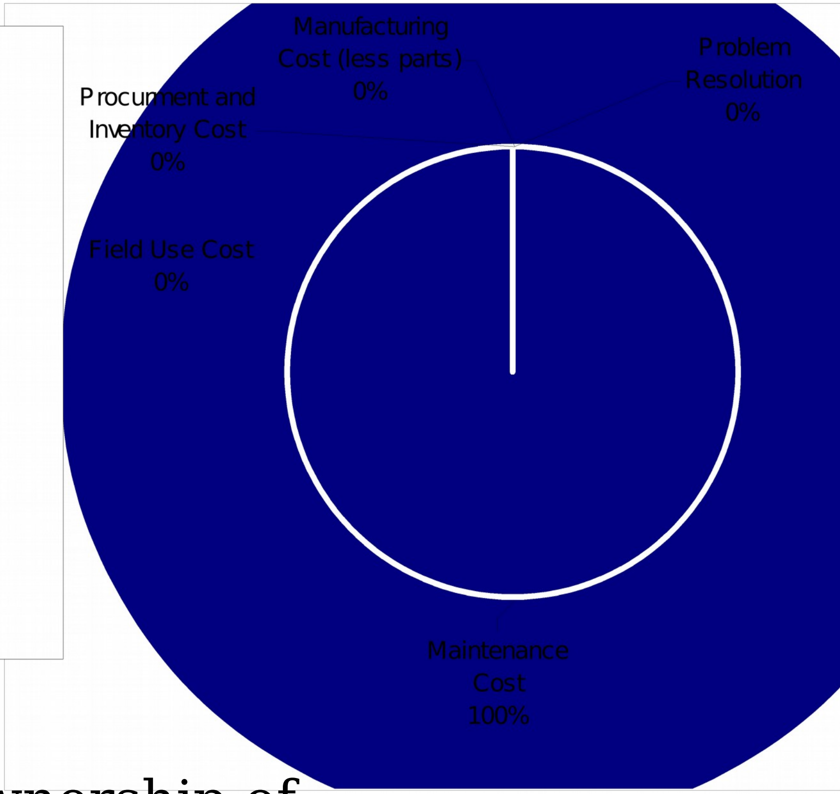
A Lower Volume Example

Same part, but with a total volume of 1290 parts (instead of 12,910,500)





A $0.015 part has a total cost of ownership of $712.82/part

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Possible Uses of the Model

- Compare the effective total ownership cost of parts during part selection
- Assess the merits of retiring parts from the part database
- Assess the value of reductions in the number of parts supported (optimal size of the preferred parts list)
- Assess the impact of part-specific supply chain disruptions
- Determine optimal part reuse across multiple products

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Reducing the Number of Part Numbers

What is the value of a 20% reduction in the number of part numbers supported?

New_maintenance_model_53-q1-base case

	A	B	C	D	E
1	DUPLICATE EFFORT ANALYSIS				
2			This model allows you to indicate which portions of the maintenance cost are duplicate effort when a part is reused		
3					
4		Maintenance Sheet Column		Duplcated	
5		O	Initial Approval	Yes	
6		P	Product-Specific Approval	Yes	
7		Q	Annual Support	Yes	
8		R	Production Support	Yes	
9		S	Annual Purchasing	Yes	
10		T	Obs Case Resolution	Yes	
11		U	Non-PSL Supplier Costs	Yes	
12		V	Reel Handling Costs	Yes	
13		W		Yes	
14		X		Yes	
15		Y	Part NRE Costs	Yes	
16					
17					
18					
19			Total duplicated maintenance cost	1112755.27	from column AE on the Maintenance sheet
20			Total duplicated maintenance cost/part	0.09	
21			Amount of part's cost duplicated	38.27%	
22			Part number reduction (%)	20.00%	20% means going from 10 different parts to 8 different parts
23					
24			Overall savings	7.65%	
25					
26					Assumptions:
27					1) All the different parts are used in equal volumes
28					2) The same total volume of parts are used even when the number of part numbers is reduced
29					

Maintenance Cost / Manufacturing Cost / Field Use Cost / Difference Analysis / Working Summary / **Duplicate Effort Analysis**

For the base case example assuming a 20% reduction in part numbers (12,910,500 volume)

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Part Reuse

- In the context of this presentation, part reuse means using the same part across many products in the enterprise, i.e., **design reuse** (<u>not</u> salvage or reuse of used parts)
- Why reuse parts?
  - Fewer PCNs to manage
  - Consolidation of procurement
  - Possible reductions in part-specific qualification cost allocated to products
  - Consolidation of lifetime buys
  - Promotes reuse of proven design solutions
  - Improves production line efficiency by reducing diversity
  - Internal standardization of some part values and sizes (RLCs)

PCN = Product Change Notice
RLC = Resistors, Inductors, Capacitors

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… But The Question Is

Is design reuse always a good thing or can you "reuse" yourself out of business?

Consider the following scenario: All of your products use (depend on) a common part. An unexpected problem (supply chain disruption) develops with the part. Instead of fighting a fire for one product, you are in trouble on every product simultaneously – you have effectively created a "single point of failure" scenario.

This leads one to hypothesize that there is a "volume of use" vs. "breadth of use" tradeoff that is critical in the part reuse decision

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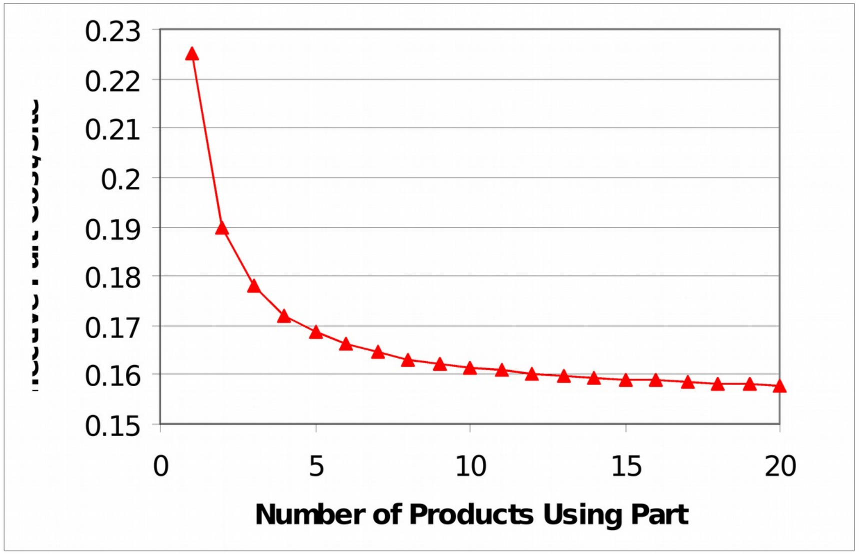
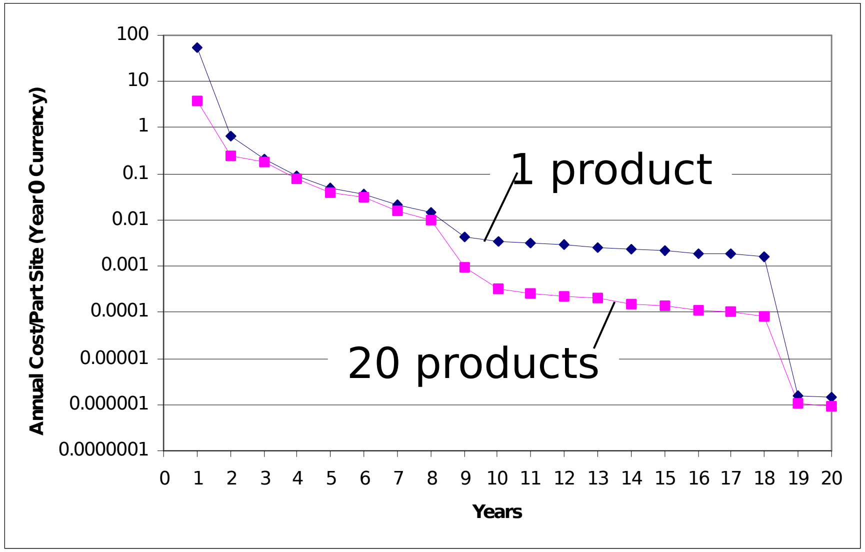
Multiple Products Using the Part



No problems encountered with the part



Nearly all of the difference is “maintenance cost” – economies of scale

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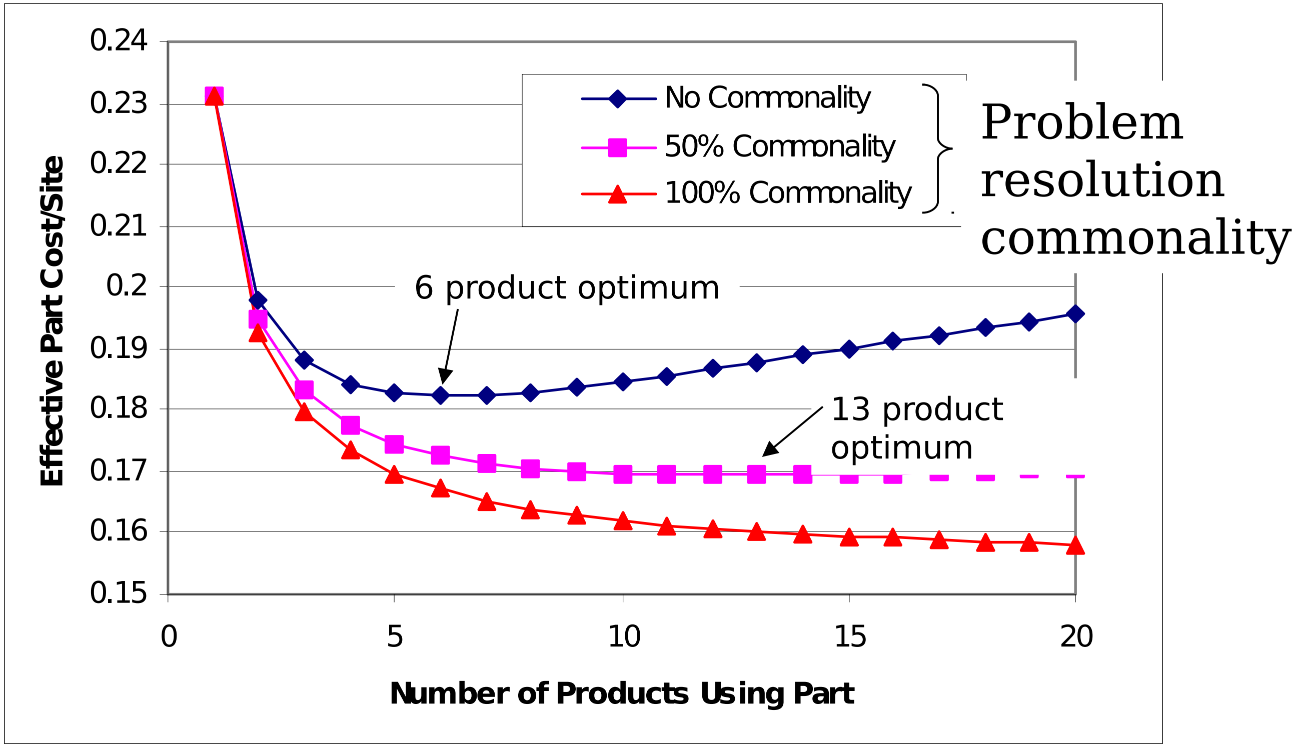
Year 5 Problem



For the analysis results given here, we have assumed that the cost of the problem resolution in a single product is C_{res} = $100,000, that we have resources to perform a maximum of one full resolution every 6 months (resolution rate = 0.5 resolutions/quarter), and the cost of unresolved problems is C_{unres} = $50,000/product/quarter.

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Summary

- Basic part total ownership cost model completed
- The model is starting to be used to explore various part management issues

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Proposed Extensions to this Work

- The following slides describe proposed CALCE Consortium projects that extend this work

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Part Total Ownership Model Extensions
(Proposed CALCE P09-S2 Project)

Planned Model Extensions

- Multi-Source Models (concurrently used sources)
- Phase-out of Parts (prior to obsolescence)
- Part Number Reduction Savings
- Price versus Volume Relationships
- Automation of Sensitivity Analyses

Model Accessibility Enhancements

- Documentation development
- Training development
- Input data refinement and simplification
- Default data identification

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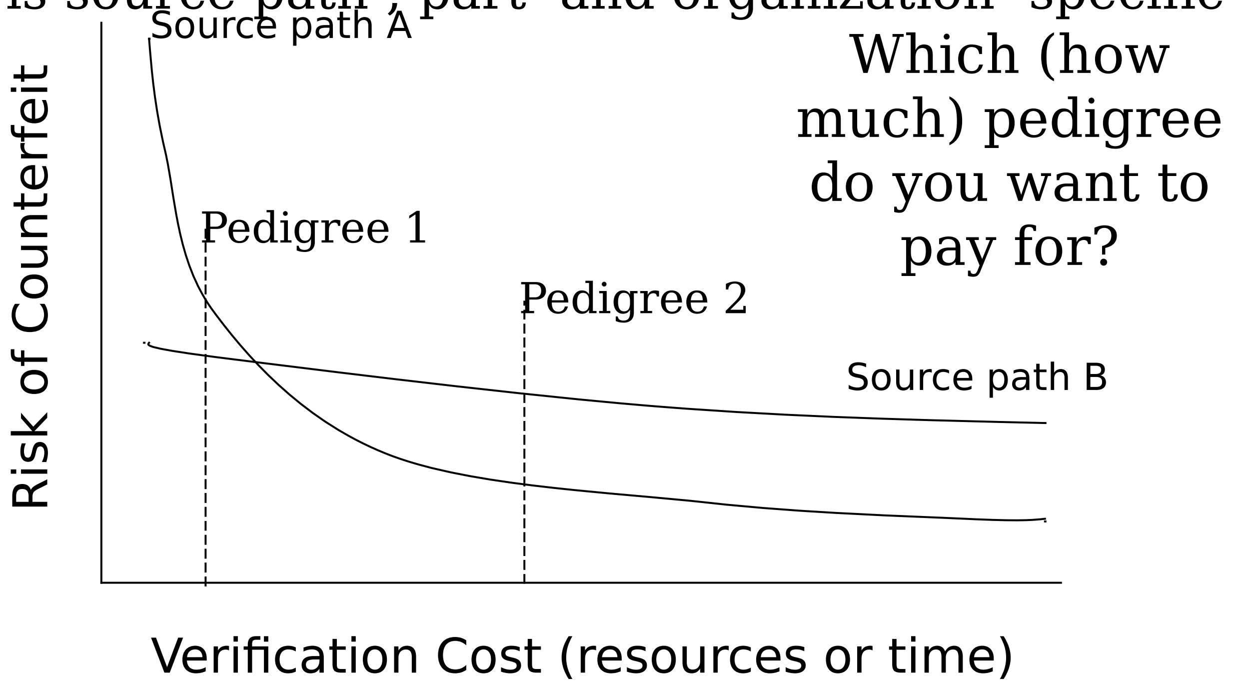
Organization-Specific Counterfeit Electronic Parts Cost and Risk Assessment

(Proposed CALCE P09-S1 Project)

- Every pedigree determination or verification action taken costs time and money, and changes the risk associated with getting a counterfeit part
- Some pedigrees are more expensive or more risky than others
- What is the real value of a pedigree (i.e., return on investment)? This value is source path-, part- and organization- specific



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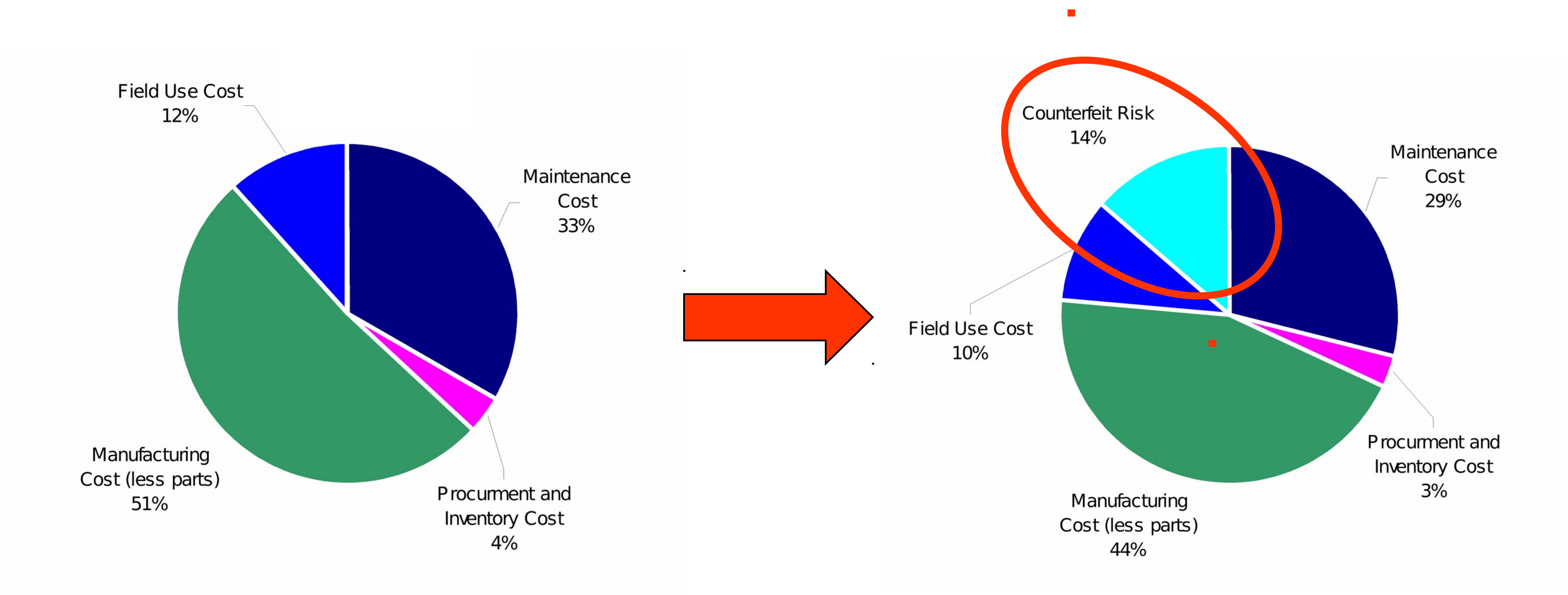
- Map the source-path and elements of the configuration control plan (pedigree) to risk/cost
  - Construct a model that allows users to customize the (known or suspected) source-path of their parts using pre-defined path elements and assess the risk as a function of source-path details and the costs of employing various levels of pedigree (i.e., tracking, documentation and other verification methods).
  - Generate graphs like the one on the previous slide
- Incorporate the source-path risk/cost into part total ownership cost estimations or sustainment models.



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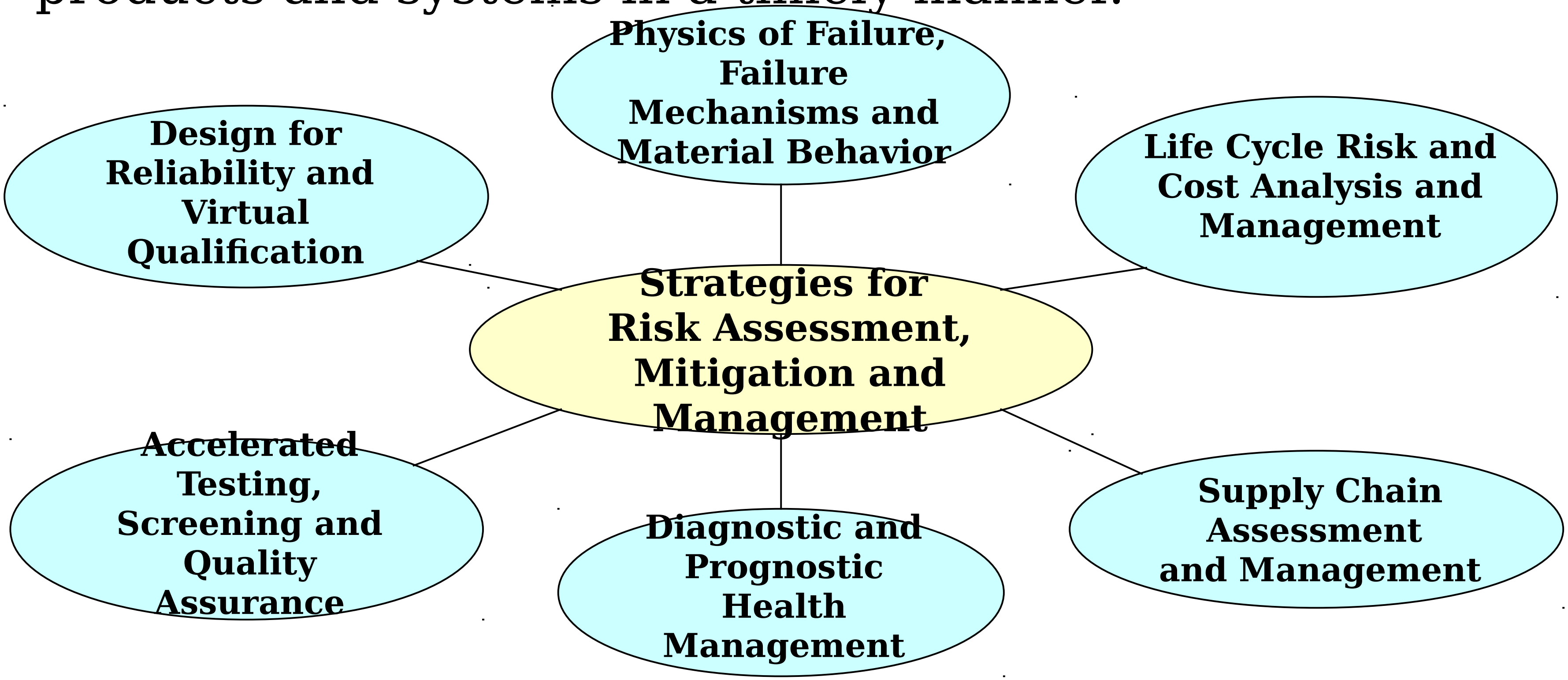
Provide a knowledge and resource base to support the development and sustainment of competitive electronic products and systems in a timely manner.



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